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# CONTROL OF RUSTY SPOT IN CHEESE FACTORIES.

H. A. HARDING AND G. A. SMITH.

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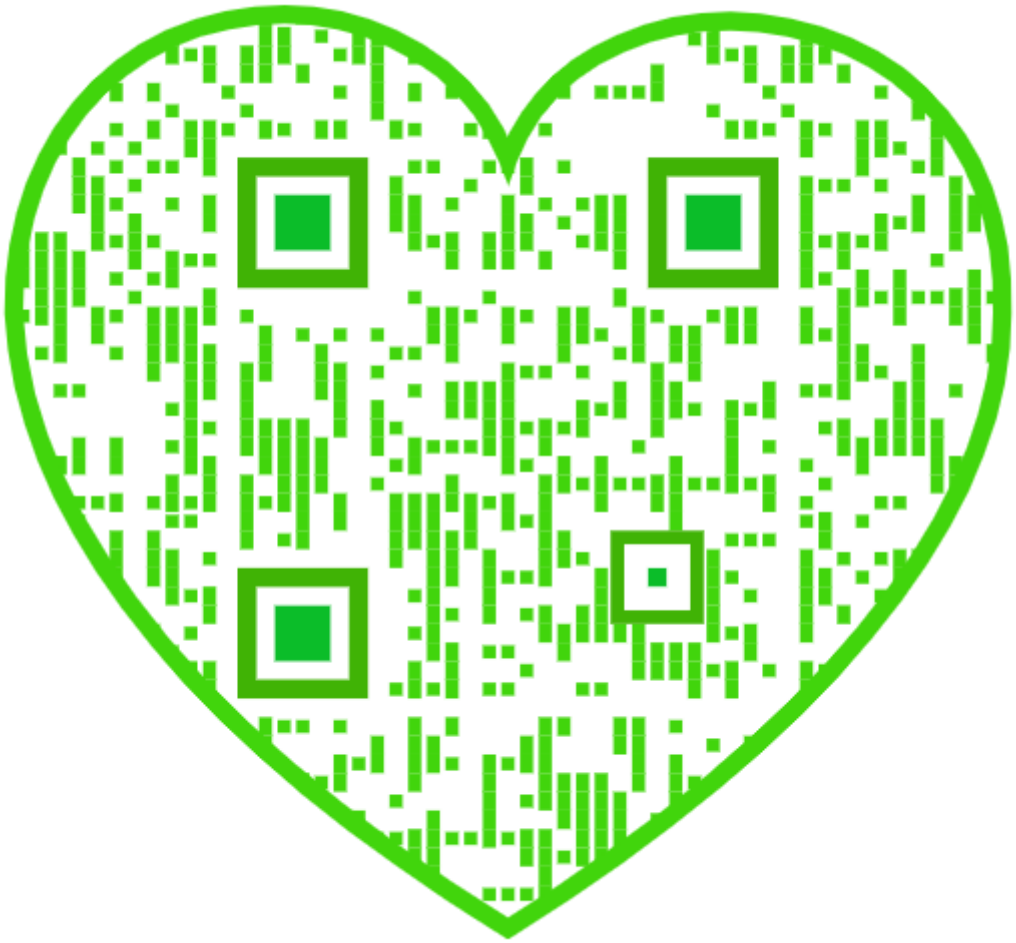

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BULLETIN No. 225.

# CONTROL OF RUSTY SPOT IN CHEESE FACTORIES.

H. A. HARDING AND G. A. SMITH.

## SUMMARY.

(1) Rusty spot in cheddar cheese is present in the output of a number of factories in this State.

(2) The rusty spots are caused by the growth in the cheese of a red bacterium, just as green streaks in stale bread are caused by the growth of a green mold.

(3) The trouble is most evident in moist home-trade cheese.

(4) The use of cheese color can not be relied upon to entirely disguise the red spots.

(5) Steaming the factory utensils as a means of combating this trouble has been tried in a number of infected factories during the past two seasons.

(6) The results thus far show that this treatment applied thoroughly three times per week will prevent financial loss except under very unusual conditions.

(7) While under ordinary conditions the factory seems to be the main seed bed of the germs, cheeses made from the milk of individual patrons indicate that at times the milk of some patrons contains the germs causing rusty spots.

## INTRODUCTION.

Among other subjects discussed in Bulletin No. 183 of this Station was the trouble known as "rusty spot in cheddar cheese." The trouble has continued to appear in factories in different parts of the State. During the past two seasons we have studied it in four infected factories. Our object in this study has been to develop a method of control which can be applied by the factoryman with ease and certainty. This bulletin gives the results of our work and observations in these factories, together with the methods which we have devised for the control of the trouble.

### ACKNOWLEDGMENT.

For obvious reasons the names of the factories and their makers will not appear in this publication but we wish to acknowledge our indebtedness to the factorymen for their active and intelligent cooperation during the progress of this investigation. Much of the success of the investigation is due to their thoughtful observations.

## GENERAL NOTES ON RUSTY SPOT.

### APPEARANCE IN CHEESE.

Usually the first intimation of trouble which the factoryman has is the statement from the buyer that part of his last shipment was cut or rejected because there were spots of a reddish color on the inside of the cheese. Plugs drawn from cheese on the shelves look as though they had been lightly sprayed with red ink or cheese-color, depending upon whether the spots are bright red or yellowish red like fresh iron rust. When a cheese is cut or broken open and the surface closely examined, the color will be found scattered in points the size of a pin point and larger. While this color occurs fairly evenly throughout the cheese it is usually most noticeable on the surface of the gas holes and other openings. If there is free moisture in these places the color will be mechanically distributed over the surface of these holes and form a yellowish red blotch which may be as large as the thumb

nail. These blotches can be readily seen at a distance of several feet and they are responsible for the financial loss because they are what attracts the unfavorable attention of the consumer. In very bad cases the whole interior of the cheese will be as highly colored as though annatto had been used, except that the color will not be evenly distributed. The spots are not present in the freshly pressed cheese but they can be found when the cheese is four to eight days old. A warm curing-room hastens their growth, while a cool one retards it. During the time the cheese is usually held in the factory the spots continue to grow but if no blotches are formed in ten days there is little probability of a cut in price.

### WHY THE PRICE IS CUT.

There is no evidence that the discoloration is in any way injurious to the health of the consumer, and we have repeatedly partaken freely of the worst cases with no bad effects. The texture and flavor of the cheese do not seem to be in any way affected by the presence of the spots. The cut in price comes from the fact that when the consumer notices the abnormal appearance of the cheese he thinks it must be bad and will not accept it. As a result the retailer returns the cheese to the wholesaler from whom he purchased it. This cheese is spoiled by being cut, and is sold to a lunch counter for a small price; while others of the affected lot are disposed of at a reduced price to the retailer who does not have a discriminating trade. Since the spots do not affect the flavor and are not injurious to health the factoryman will naturally feel that this treatment is unjust; but the discrimination merely illustrates well the old proposition that in order to cater to a first-class trade, the producer must consider appearance as well as quality. In considering this trouble from a commercial standpoint it should be remembered that, unless the red points are of sufficient size to be readily seen or blotches are formed in the cheese, there is little probability of a cut in price.

### RUSTY SPOT NOT TABLE STAIN.

This spotted appearance of the inside of the cheese should not be confused in any way with the pink discoloration of the rind and bandage by some termed table stain. This latter trouble is

often noticed, especially in damp curing rooms, and is due to the action of mold. Table stain can be controlled by carefully washing the shelves to remove the mold, followed by burning sulphur, and attention to the ventilation.

### FALSE THEORIES AS TO CAUSE OF RUSTY SPOT.

Many explanations have been advanced by different persons to account for the appearance of these rust-colored spots in cheese. From their color it was at first supposed that the spots were due to iron rust from handling the milk in old cans or rusty vats. A chemical examination showed that these rusty looking portions contained only a trace of iron, no more than is found in a normal cheese. Some buyers held that the trouble was due to adding cheese-color irregularly, but the trouble was very bad in factories where no color had been used.

Poor salt has been blamed, but the trouble is found in factories using the very best grades of salt and has come and gone while the same barrel of salt was in use.

The fact that the trouble does not appear until the cheese is some days old and that from this time it continues to increase for some days plainly indicates that it is due to the action of some form of life in the cheese.

## HISTORY OF RUSTY SPOT.

### OUTBREAKS IN THE STATE.

The earliest reported appearance of rusty spot in this State was in St. Lawrence County in 1883. For many of the facts connected with this outbreak we are indebted to Mr. W. W. Hall, who was a resident of this county and prominent in cheese matters at that time. In July of that year the rusty spots were noticed in the cheese at the Elmdale cheese factory near Gouverneur.

The factorymen were utterly at a loss to account for them as they were making white cheese and had used no coloring matter. The trouble did not develop to any considerable extent and about September 1 it disappeared for the remainder of that year. The following season it was much worse and continued longer.

The trouble spread until nearly all of the factories in that section were affected to such an extent that at times they resorted to coloring the cheese in order to cover up the spots. In some cases the factory would have no trouble until the autumn months, when it would suddenly develop very rapidly, quite often becoming so marked that it was impossible to cover it with annatto. The spots were rarely discovered in the early spring months, yet there were some factories where they showed to a greater or less degree throughout the whole season.

About ten years ago this trouble developed in the factory at Hailesboro. This factory had good drainage and was well built and well managed. The trouble continued for a number of seasons and the financial loss was some hundreds of dollars. The method of manufacture was changed and a very dry, high-colored cheese made, but the trouble was unchecked and the spots showed through the cheese color. As a last resort the making of cheese was abandoned and the cream was made into butter, although the financial returns were then less than those obtained from good cheese. The making of butter at this factory is still continued.

We have not received a report of a serious outbreak of the trouble in St. Lawrence County during the last few years.

The Miller factory at Constableville had an outbreak of the spots about 1888. Here it was so severe that coloring the cheese failed to cover the discolorations. The factory lost heavily both in patronage and in the price of its product. The trouble continued until the total destruction of the factory by fire some years later. A modern factory was built near the site of the old one and there has been no return of the spots reported.

The old Harrisburg factory in Lewis County had an outbreak of the trouble in August, 1895. Reappearing in April, 1896, it lasted throughout the season and was so bad that the blotches showed through the cheese color. There was less of it in 1897 and since that time it has not appeared. An old upright press which was discarded in the overhauling which the old Harrisburg factory received while fighting the rusty spots was taken to the adjoining Silver Springs factory. Trouble soon developed in the latter and continued until it resulted in the closing of the

factory. After standing idle one season the factory was thoroughly overhauled and partially rebuilt. Since that time no trouble has been reported.

The trouble has been observed in nearly all sections of the State where white cheese is made. Cases of it have been reported to us from St. Lawrence, Jefferson, Lewis, Oneida, Oswego, Allegany and Cattaraugus counties.

## PREVIOUS SCIENTIFIC WORK.

In 1896 W. T. Connell studied an outbreak of rusty spot at a Canadian factory. From the infected cheese he isolated an organism which he named *Bacillus rudensis*[1] and when a starter of this organism was added to a vat of good milk the rust-colored spots were reproduced in the cheese. He concluded that the trouble was largely due to air-borne infection from the red growth along the factory drains.

Beginning in 1899 we have repeated and extended these observations as to the cause of the discolorations in the cheese. We have studied outbreaks in a number of factories in widely separated portions of this State and in all cases we have found *Bacillus rudensis* present in large numbers in the rust-colored spots in the cheese.[2] We have many times repeated the experiment of adding a starter of this organism to a vat of good milk and have reproduced the rusty spots in the resulting cheese.

## NECESSITY FOR THE PRACTICAL APPLICATION OF THE ABOVE RESULTS.

The work of Connell showed that *Bacillus rudensis* was at least one of the germs causing rusty spot in cheddar. Our own work has rendered it probable that it is the only germ directly concerned with this trouble.

Knowing only this fact we were not able to give specific advice in the practical problems which confront the dairymen in infected factories, but the fact was valuable because it gave a sound basis upon which to formulate methods of controlling the trouble.

[1] Connell W. T. Discoloration of Cheese. Canadian Dept. of Agr., Bul., 1897.

[2] Harding, H. A., Rogers, L. A., and Smith, G. A. Notes on Some Dairy Troubles. N. Y Agr. Exp. Sta. Bul. 183, Dec. 1900.

In planning methods we have kept in mind the fact that to be of most benefit the process must be neither so costly as to discourage the factoryman nor so vague in its directions as to confuse him and cause him to spend his time in fruitless effort.

This publication is a record of our attempt to apply our knowledge to actual conditions as they are found in infected factories.

## INVESTIGATIONS.

### WORK AND RESULTS AT FACTORY NUMBER ONE.

Factory Number One is a large one in the northern part of the State and has long had an enviable reputation for turning out a fine product. The building, though an old one, is in good repair and its location, while high and dry, is on a level area not affording good natural drainage. It produces a variety of cheese, both colored and uncolored, but makes a specialty of a small-sized cheese for home trade.

The first outbreak of rusty spot occurred in the autumn of 1900 after receiving patronage from a neighboring infected factory. The trouble was not discovered until a large stock of cheese had been accumulated for the winter trade and the financial loss was correspondingly heavy. During the winter the question was put to us very forcibly: "What shall we do to stop the trouble? The financial loss is more than we can stand and our business will be ruined if the rusty spots can not be controlled."

Although every thing about the factory seemed in good order we recommended as a preliminary step the thorough cleaning of the factory and the whitewashing of the inside walls. This was done. Early in May the spots again appeared in the cheese, showing that the cleaning had not removed the trouble. We then discussed the advisability of using formalin to complete the disinfection. The work of Connell had laid stress upon the danger of contaminating the curd through the air. The advantage of formalin lay in its ability to disinfect the walls, ceiling and floor as well as the tools and thus decrease the probability of germs being carried to the curd. However the cost of the amount of formalin necessary for a single treatment of the factory was found to be over ten dollars. Added to this was the difficulty

of making the room sufficiently tight to hold the gas for the required length of time. On account of the work and expense involved as contrasted with the simplicity and effectiveness of the steaming process, later to be described, we abandoned the idea of using formalin.

On May 14, in addition to the ordinary cleaning of the tools, the curd mill was submerged in hot water for an hour. When the cheese of the following day was examined after the necessary interval no spots were found. The occasional boiling of the mill was continued but the spots in the cheese again became plentiful. The red points were abundant in all the cheese made between June 25 and July 3. In the cheese of the latter day the points were very closely set and could be readily seen by the ordinary observer.

After the cheese was in press on July 3, the curd mill, knives, rakes, conductors and everything which came in contact with the milk, were put into a vat, covered with water and heated with steam. It took two hours to heat this water to 160° F. and consumed a large amount of steam. The process had the further disadvantage that the hot water tended to warp the wooden utensils. The weigh can and remaining vats were heated with direct steam.

This heating was repeated on July 12, except that the water was left out of the vat and the utensils were heated with direct steam. In doing this a heavy cloth cover was drawn over the vat to retain the steam, and the temperature was raised to 180° F. and held there 15 minutes so that the heat would penetrate all portions of the tools. The consumption of steam, while considerable, was far less than when the water was used and the heating of a vat full of tools could be completed in 20 minutes.

The effect of this treatment upon the cheese was prompt and satisfactory. The cheese made July 4 contained less than $\frac{1}{100}$ as many red points as that made the preceding day and these red points remained small and hard to find at the end of 12 days.

While the activity of the germs was checked by this heating they were not all removed, and in the succeeding days the spots appeared in varying numbers, but it was only in the cheese of July 12 that they were recorded as large enough to be easily seen.

As it chanced, the second steaming occurred immediately after this cheese was made; and ten days later only a few points could be found in the cheese made July 13.

In connection with our work we made a number of trips to the factory to observe the treatment in operation, to compare ideas with the factorymen and to examine the cheese upon the shelves. These latter observations were supplemented by others made upon samples taken by the factorymen from the cheese of each date just as the latter was ready for shipment and mailed direct to us. In one or both of these ways we were able personally to pass upon the product of each day from June 27 to August 17 beside making occasional observations before and since that time.

While the cheese of this factory was of the home trade type it was so carefully made during this season that little free moisture was present, and as a result the formation of blotches was reduced to a minimum.

Although the trouble was successfully checked the factoryman was naturally desirous of having it entirely removed from the factory. As has been mentioned, there had been a transfer of patronage from a neighboring infected factory in the season of 1900, and it was natural to suppose that the patrons had brought the germs with them. The most probable source from which they could have obtained these germs was through the whey from this factory.

Since in this way the whey had been brought under suspicion as being a means of spreading the trouble the factoryman was desirous of pasteurizing his whey and thus cutting off the transfer to his patrons of germs to be later returned with the milk.

To accomplish this a $\frac{3}{4}$-in. steam pipe was connected with the whey vat and about 10 ft. of the pipe placed around the bottom. The vat received the whey from about 10,000 lbs. of milk. The following observations were made on the first heating July 24. Heating began at 11.00 a. m. when the whey showed a temperature of 95° F.; by 11.20 this had risen to 140° and by 12.05 to 162°. Steam was then turned off and the whey cooled slowly, the temperature at 2.15 being 158°, at 3.30 140°, and at 7.00 a. m. the next day 110°. This high temperature in the morning was probably due to a slight inflow of steam through valve leakage.

The heating to 162° F. was repeated on July 25, 26 and 27, but was temporarily discontinued on account of the leaking of the vat. As a result of the heating there was a slight settling out of the solids, but any difficulty in a fair division of the whey could be readily overcome by an occasional stirring. On the following morning the whey was still sweet to the taste, indicating that fermentation had been checked and that the whey was in prime condition for feeding.

The heating of the factory utensils was repeated on July 24 and 27, and August 3 and 9. Examination of cheese made during this period showed that after July 24 the spots decreased in number so that during a considerable portion of the time few or none could be found.

After the beginning of the treatment in July there was very little of the cheese where the spots would be detected by any but an experienced eye and there was no financial loss on this account. Since the close of our regular observations no outbreak has occurred, and occasional examinations of the product of this factory have failed to show any red points.

At the beginning of the trouble we had recommended that all the cheese be colored to guard against loss. This was done until after the heating had shown itself to be effective when a part of the cheese was regularly made uncolored during the remainder of the season.

### EXPERIENCE IN A BRANCH OF FACTORY NUMBER ONE.

During the season of 1901 a slight outbreak of rusty spot occurred at a branch of this factory. Steaming of the vats and utensils, according to the same plan which had been followed at the main factory, was immediately begun, with the result that the spots disappeared in a short time and have not since reappeared.

### WORK AND RESULTS IN FACTORY NUMBER TWO.

In Factory Number Two, which was widely separated from Factor Number One, there was an outbreak of rusty spot in the autumn of 1900, causing a considerable financial loss. This fact was reported to us in November too late to do anything with it at that time. The trouble again became so marked as to attract

attention in July, 1901. We visited the factory on July 31 and found red points in stored cheese of the preceding May.

The factory is a wooden building in good repair situated in a valley near a small creek which affords opportunity for good drainage, but this has not been utilized to the fullest extent. The whey vat was in fair condition and located about 30 ft. from the factory and at the side of the creek. The inside of the factory was not ceiled but side walls had been whitewashed during the season. The product was a moist, loose-textured home-trade cheese, very favorable for the development of red spots or blotches.

An examination at the factory on July 31 showed that distinct blotches had been formed in the cheese of July 17, 20, 23, 25 and 26, and red points were evident in cheese of July 27 and 28. A later examination of samples on August 9 and 13 showed blotches in cheese of July 27, 28, 30 and 31.

Owing to his desire to sell the greatest possible amount of water at cheese prices the maker wished to continue, if possible, the manufacture of this very soft cheese. As a precaution we recommended coloring the cheese—which was begun August 2 and has been continued to the present time.

On July 31 all of the utensils which came in contact with the milk were placed in the vats and steamed at 180° F. for 15 minutes.

A curd sink was in use at this factory and this was treated in the same way as the vats except that from its more open construction the work could not be as satisfactorily carried out. The weigh can was inverted and the steam introduced through the faucet. This heating was repeated on August 1, 2, 3, 5, 6, 7, 8, 9. 10, 12, 15 and 17. A steam connection was made with the whey vat and the whey was heated to 145° on August 2, 3, 5, 6, and each succeeding alternate day until the 17th. At this time the heating was discontinued because the vat was leaking.

During the first four days after the beginning of the heating, the milk was handled in two vats and there was a marked difference in the number of red points present in samples of the cheese from the two vats on each day. After this time the milk was

made up in a single vat and no further observations of this kind were possible.

On August 1 and 2 the cheese from one vat was blotched but the use of cheese-color prevented the blotches from showing in the cheese of August 2. The cheese of August 3 showed only an occasional red point and after this date the points, though present, were not sufficiently numerous to cause trouble until August 15. On this date blotches were formed, though fortunately they were obscured by the cheese-color. It so chanced that the steaming of the utensils occurred on this day and not a single red point could be found in the sample from the cheese of August 16. The small red points in the colored cheese were so difficult to detect with the unaided eye that the maker overlooked them and thought that the trouble had disappeared. Accordingly he restricted the heating to the utensils placed in the curd sink on August 19, 21 and 31, and then entirely ceased the steaming. Left to itself the trouble increased again until the cheese-color failed to cover up the blotches on August 28, September 1, 3, 6, 7, 9, 10 and 11. The factory was visited on September 10 and the actual condition brought to the attention of the maker. After this date the vat and utensils were steamed regularly three times per week. The number of spots decreased rapidly, and during the first half of October entirely disappeared for over two weeks.

The principal results of this season's experience at this factory may be summarized as follows:

(1) In making moist, home-trade cheese, coloring alone can not be relied upon to cover up rusty spot.

(2) The marked difference in the development of the spots in cheese made upon the same day in different vats can best be explained by assuming an introduction of germs with the milk.

(3) In all but exceptional circumstances careful steaming, three times per week, will keep the trouble below the point where it will cause financial loss.

While the spots were kept below the point where they would cause financial loss upon the cheese, their almost constant presence indicated that there was a seed bed which our present methods did not reach. The work of 1902 was mainly directed toward determining this source of supply.

WORK AND RESULTS AT FACTORY NUMBER TWO IN 1902.

Although we kept in touch with the factory from the opening of the season, it was not until July 24 that we received samples showing the red points.

On July 31 we collected quart samples from the milk of each of the 31 patrons, and from each sample we made a little cheese, taking care to reduce, as far as possible, the chances of contamination from the factory. The details of this method of making cheese from milk samples are given on page 323.

The little cheeses were at once brought to the Experiment Station and cured at 70° F. When examined on August 15 red points in abundance were found in the cheeses representing 5 patrons and a single red point in each of 3 others. Cultures from a number of these red points showed that they were really due to the presence of *Bacillus rudensis*. The remaining 25 samples failed to show any red points. Owing to a misunderstanding we failed to receive samples of the factory cheese made on this date.

Samples were collected from all of the patrons and little cheeses were made August 19 and 20 with the same precautions as before. When examined, August 30, one cheese of August 19 and two of August 20 contained a very few red points. These three samples represented three patrons, but two of them were among the eight whose samples had produced red points July 31.

The steaming of the factory utensils, which had been followed the preceding season, was begun in July at the first appearance of spots in the cheese. When duplicate samples from the factory cheese of August 19 and 20 were examined no red spots could be found.

As the result of these observations and particularly of the examination of July 31 the presence of an outside source of contamination was made fairly certain, and strong suspicion was attached to the patrons as being the source of the trouble.

No further outbreak occurred this season and consequently we were unable to carry further our investigation of this point at this factory.

The results of the treatment during the two seasons is summed up by the maker in a letter of recent date as follows: "I have

had very little trouble this season. Some showed in the cheese of September 23 to 28, but I could not find a trace of it in the October cheese. I notice that if my cheese is very soft and wet the spots are more likely to appear. I find the steaming process very satisfactory, for in this way I can keep the trouble down so that it is not noticed by the buyers."

WORK AND RESULTS AT FACTORY NUMBER THREE.

The patrons of Factory Number Three suffered from rusty spot in an old factory for a number of years without finding anything which removed the trouble. The cheese was colored very high, which partly concealed the spots, but the financial loss was heavy.

As the owner was unwilling to renovate the old factory the farmers put up a new one in the fall of 1901. This may fairly be considered a model of its kind, well built, the inside walls ceiled throughout, a cement floor in the making room and everything so constructed as to be easily kept clean. The utensils were new, except a steel gang-press which was brought with them from the old factory after having been used there about a year.

The new factory opened in March, making a white, home-trade cheese, but the presence of red spots was soon discovered. At their request we visited the factory April 10 and found a well-made lot of cheese, very generally affected with the rusty spot and blotched in most cases. They had returned to the use of cheese-color just before our visit and we instituted the same method of steaming vats and utensils, which had been practiced at the other factories, with the added feature that an old creamery tank was fitted up for steaming the hoops and followers. This steaming was repeated three times per week during a considerable portion of the season.

The factory was visited a number of times, and samples were received regularly until the middle of May and at irregular intervals from that date until the close of the season. While the red spots did not permanently disappear from the cheese they were so small and so infrequent as not to cause financial loss.

The attempt was made on April 10, 11 and 21, July 25 and August 13 to determine the presence of *Bacillus rudensis* by

making a small cheese from a sample of the milk of each patron, as described on page 323. The first three of these attempts were failures, due to our lack of experience in the making of this kind of cheese, while at the two later dates there was an almost entire absence of the germ, as shown by the factory cheese.

As the result of these examinations the red spots developed in two samples from each of two patrons and in one sample from each of two others, but the numbers present were too small to make it advisable to push the inquiry farther.

### OBSERVATIONS AT FACTORY NUMBER FOUR IN 1900.

Although Factory Number Four was, in point of time, one of the first with which we worked the discussion of our observations has been reserved because of their greater number and interest.

The first outbreak occurred early in October, 1900, but we were not called to the factory until late in the following month just as the factory was closing for the season.

The building was an old one and had apparently received few repairs. The wooden floor of the making room was broken through in a number of places, allowing the floor slops to flow through upon the stones below, which were covered with the accumulated filth of years. The whey vat had not been cleaned in weeks because it was so old that on being emptied and dried a little it would no longer hold whey. As it was, the leakage from this source maintained a large mud hole. The drainage, which was by nature fair, had been neglected. The curing room and utensils were clean and in good order, and the maker was evidently doing his best under very adverse circumstances.

Little could be done aside from explaining the cause of the trouble and urging the necessity of a thorough cleaning up and preparation for the outbreak, which was almost certain to come the following season.

### WORK AND RESULTS AT FACTORY NUMBER FOUR IN 1901.

July 17 we received word that an outbreak of rusty spot had occurred and we reached the factory the following day. A striking change in the factory and its surroundings was evident. The

drainage had been improved, a new whey vat and connections had replaced the old, the inside of the making room had been ceiled up, and, best of all, a cement floor had replaced the old wooden one and buried the filth beneath it.

With the opening of the season, the factory had begun the manufacture of an extremely moist, uncolored, home-trade cheese of good quality, for which trade connections at good prices were quickly established. The resulting high dividends caused the return of the patronage which had left as the result of the financial loss the preceding season, and at this time cheese was being made in three vats.

The results of our examination of the cheese on hand July 20 can best be condensed into a table.

OBSERVATIONS OF CHEESE AT FACTORY NO. 4, ON JULY 20, 1901.

| Date made. | Vat. | Appearance of cheese. |
|---|---|---|
| July 6 | West | No spots. |
| 6 | Middle | Few red points. |
| 6 | East | No spots. |
| 7 | West | Very bad—large yellowish red blotches in holes near the rind. |
| 7 | Middle | Much less than in west vat. |
| 7 | East | Very little showing. |
| 8 | West | Little except near outside of cheese. |
| 8 | Middle | Very little. |
| 8 | East | Very badly blotched. |
| 9 | West | Very bad. |
| 9 | Middle | Points fairly plenty. |
| 9 | East | Little more than in middle vat. |
| 10 | West | Fairly plenty. |
| 10 | Middle | Little more. |
| 10 | East | Least. |
| 11 | West | Plenty. |
| 11 | Middle | Plenty—shows small pieces of red curd. |
| 11 | East | Presence of points doubtful. |
| 12 | West | As little as any since July 6. |
| 12 | Middle | Little more than west vat. |
| 12 | East | About same as middle vat. |
| 13 | West | Few points; 3 or 4 on cross section of plug. |
| 13 | Middle | None found. |
| 13 | East | About same as west vat, very little. |
| 14 | West | Blotched, especially near rind. |
| 14 | Middle | Points plenty, more numerous near rind. |
| 14 | East | Points plenty, more numerous near rind. |
| 15 | ..... | No spots showing in cheese. |

From the above notes it will be observed that the trouble appeared as an outbreak or wave which reached its crest about July 9, after which it tended to die down of its own accord. This phenomenon has been since observed on a number of occasions, but no satisfactory explanation has yet been found.

It will further be observed that there is often a marked difference in the amount of discoloration produced in the cheese from different vats on any given day.

We have already commented upon similar observations in connection with our work at Factory Number Two, and in this factory, with its larger number of vats, we have observed repeated examples of this relation during the two past seasons. During both seasons the trouble was usually most marked in the west vat, which received the milk of the first patrons.

On July 15 the factorymen had made up separately a portion of the milk from each of 30 patrons. There was the theoretical objection that, in making up these samples in open vats and with a single set of tools, a mixing of the germ content of the various samples would take place; and there was also considerable opportunity for contamination by germs from the factory air.

When these samples were examined July 20 six of the thirty showed a small number of red points.

Owing to the above objections to the method of manufacture and to the small number of spots found in any case, little stress was laid upon these results, but when it was found that the factory cheese, made the same day, showed only an occasional spot in the product of one vat and none in the cheese from the other vats these observations added something to the probability of an outside source of contamination.

The same method of heating the vats and utensils which was then giving satisfaction at Factory Number One was started at Factory Number Four on July 19.

The high percentage of moisture in the cheese which this factory was making gave very favorable conditions for the formation of blotches, but owing to trade relations it was desirable to continue the manufacture if possible. The presence of these blotches had led the maker to use cheese-color in an ineffectual attempt to cover up the discolorations and we advised continuing its use.

However, the disappearance of the spots was so marked that after August 1 white cheese was made throughout the season, with the exception of a short time, about October 1. We have condensed into the following table the results of our observations of the cheese during the entire season.

OBSERVATION ON CHEESE AT FACTORY NO. 4, 1901.

| Date of observation. | Date made. | Heated in P. M. | Vat. | Condition of cheese. |
|---|---|---|---|---|
| July 26 | July 14 | — | W M E | All faintly blotch'd. |
| | 15 | — | W | Only occas'nal spot. |
| | | | M | No spots found. |
| | | | E | No spots found. |
| | 16 | — | W | 50 small pts. in plug. |
| | | | M | 5-6 small pts. in pl'g. |
| | | | E | 50 small pts. in plug. |
| | 17 | — | W | 5 6 small pts. in pl'g. |
| | | | M | 2 small pts. in plug. |
| | | | E | Faintly blotched. |
| | 18 | — | W | Faintly blotched. |
| | | | M | Faintly blotched. |
| | | | E | 3 small pts. found. |
| | 19 | + | W | No spots found. |
| | | | M | 4 small pts. found. |
| | | | E | No spots found. |
| Aug. 6 | 20 | + | W M E | No spots found. |
| | 21 | — | W M E | No spots found. |
| 13 | 23 | + | W M E | No spots found. |
| | 24 | — | ... | No spots found. |
| | 25 | + | W | No spots found. |
| | | | M | Many small pts. |
| | | | E | No spots found. |
| | 26 | — | W | Many small red pts. |
| | | | M | Few scattering pts. |
| | | | E | No spots found. |
| 8 | 27 | + | ? | Few small pts. |
| Aug. | July 28 | — | W | Less than other two. |
| | | | M | Found plenty pts., small. |
| | | | E | Found plenty pts., small. |
| | 29 | — | ? | Pts. plenty—almost enough to blotch. |
| | 30 | + | ? | Many small pts. |
| 17 | Aug. 1 | + | W | Only 1 pt. found in plug. |
| | | | M | Only 4 pts. found in plug. |
| | | | E | Only 3 pts. found in plug. |
| | 2 | — | W | Badly blotched. |
| | | | M | 4 pts. found in plug. |
| | | | E | No pts. found in plug. |
| | 3 | + | W | 1 pt. found in plug. |
| | | | M | 1 pt. found in plug. |
| | | | E | No pts. found in plug. |
| | 4 | — | W M E | No spots found. |
| | 5 | — | W M E | No spots found. |
| | 6 | + | W | No pts. found. |
| | | | M | Few very fine pts. |
| | | | E | No pts. found. |
| 21 | 7 | — | W | No pts. found. |
| | | | M | No pts. found. |
| | | | E | Few fine pts. |

OBSERVATION ON CHEESE AT FACTORY NO. 4, 1901—Continued.

| Date of observation. | Date made. | Heated in P. M. | Vat. | Condition of cheese. |
|---|---|---|---|---|
| Aug. | Aug. 8 | + | W M E | No pts. found. |
| | 9 | — | W | Few fine pts. |
| | | | M E | No pts. found. |
| 21 | 10 | + | W | No pts. found. |
| | | | M | No pts. found. |
| | | | E | Very many small pts. |
| | 11 | — | W M E | No pts. found. |
| | 12 | — | W M E | No pts. found. |
| | 13 | + | W M E | No pts. found. |
| | 14 | — | W M E | No pts. found. |
| 31 | 15 | + | M | Small pts. fairly abundant. |
| | | | E | No pts. found. |
| | 16 | — | M | No pts. found. |
| | | | E | 4 pts. in plug. |
| | 17 | + | M | Few pts. |
| | | | E | 2 pts. found. |
| | 18 | — | M | No pts. |
| | | | E | Few pts. |
| | 19 | — | M E | No pts. found. |
| Sept. 10 | 20 | + | M E | No pts. found. |
| | 21 | — | M | No pts. found. |
| | | | E | Single pt. found. |
| | 22 | + | M | No pts. found. |
| | | | E | Faint film on holes. |
| | 23 | — | M E | No pts. found. |
| | 24 | + | M | No pts. found. |
| | | | E | Slightly blotched. |
| Sept. | Aug. 25 | — | M E | No pts. found. |
| 17 | 26 | — | M | No pts. found. |
| | | | E | Few well developed points. |
| | 27 | + | M | Few scattering pts. |
| | | | E | Faint film on many holes. |
| | 28 | — | M E | No pts. found. |
| | 29? | + | M | Many small pts. |
| | | | E | No pts. |
| Oct. 2 | Sept. 8 | — | M E | No pts. |
| | 9 | — | M E | No pts. |
| | 10 | + | M | No pts. |
| | | | E | Few pts. |
| | 11 | — | M E | No pts. found. |
| | 12 | + | | No pts. found. |
| | 13 | — | M | No pts. found. |
| | | | E | Few pts. |
| | 14 | + | M | No pts. |
| | | | E | Few pts. |
| 9 | 15 | — | | No pts. |
| | 16 | — | M | No pts. |
| | | | E | Fine points fairly abundant. |
| | 17 | + | M | No pts. |
| | | | E | Few pts. |
| | 18 | — | | No pts. |
| | 19 | + | | No pts. |
| | 20 | — | | No pts. |
| | 21 | + | | No pts. |
| 15 | 22 | — | M | No pts. |
| | | | E | 1 pt. |
| | 23 | — | | No pts. |
| | 24 | + | | |
| | 25 | — | M | Fairly plenty. |
| | | | E | No pts. |

OBSERVATION ON CHEESE AT FACTORY NO. 4, 1901—Continued.

| Date of observation. | Date made. | Heated in P. M. | Vat. | Condition of cheese. |
|---|---|---|---|---|
| Oct. | Sept. 26 | + | M E | Shows plainly. |
| | 27 | — | M E | Badly blotched. |
| 24 | Oct. 8 | — | M E | Blotched<br>Many fine pts. |
| Oct. | Oct. 9 | + | M E | 2 pts.<br>Many fine pts. |
| | 10 | — | M E | Few scatter'g pts. |
| | 11 | — | M E | Few small pts.<br>No pts. |
| | 12–18 | .... | ... | No pts. fr'm eith'r v't. |

The collection of such data over so long a period from a factory located a hundred miles from the Experiment Station would have been impossible without the hearty cooperation of the factorymen. As far as possible we have given the results of our own observations at the factory and have supplemented these with the results from samples sent us by the factorymen. The cheese made each day was dated as it came from the press, and practically the only opportunity for error in sampling lay in the chances of mixing the product of different vats. This might occur through the distribution of the residue after filling the last hoop in any vat or through a confusion in placing the cheese upon the shelves. Constant care was exercised, and we believe that the data as given are substantially correct.

The omissions during the first and the last weeks in September were accidental, and the latter is particularly to be regretted, since it occurred just at the time of an outbreak. The only predisposing cause which could be found within the factory at this time was a change in the method of manufacture, which left considerable free moisture in the curd and allowed the small number of germs present to do a maximum amount of damage.

During a considerable portion of the season the red points were so small and scattering that they would have been overlooked without a magnifying glass, and even with this aid they could not always be found. At no time were they sufficiently evident to cause financial loss except in one vat on August 2 and in a half dozen vats during late September.

These favorable results were obtained notwithstanding the fact that during this time the cheese contained a high percentage of moisture and was uncolored, making the conditions very favorable for the formation and observation of blotches.

A single set of tools was used in all the vats, and the marked showing of spots in the product of one vat, while they were practically absent in the others, suggested that the inoculation of a considerable quantity of *Bacillus rudensis* was necessary in order to result in any considerable showing in the cheese.

The same observations regarding the difference in the product from different vats on the same day, which is well illustrated on August 2, could be best explained by the assumption that there was an outside source of contamination which our heating process did not reach and which at irregular intervals furnished a heavy inoculation of *Bacillus rudensis* in certain vats.

For the purpose of testing this assumption samples were collected in steamed quart fruit jars from the milk of 21 patrons on October 24 and each manufactured into a cheese with the least possible exposure to contamination. When these small cheeses were examined on November 5 red spots were fairly plenty in two and a few were found in two others.

## WORK AND RESULTS AT FACTORY NUMBER FOUR IN 1902.

*Method of making test cheese.*—Encouraged by the results of our preliminary trial in October, 1901, we devoted considerable time to studying the method of making small cheeses in fruit jars.

This method was introduced to the dairy industry about twenty years ago by H. A. Rees, of Lowville, State Cheese Instructor, as a means of determining the quality of patrons' milk. The same method for determining the same point was more recently rediscovered at the Wisconsin Dairy School and called the Wisconsin Curd Test.

In applying this method to the determination of the presence of *Bacillus rudensis* in the patrons' milk we first carefully washed and steamed the fruit jars to destroy the germs which have remained from previous tests. Samples were collected in these jars as the patrons' milk was being emptied into the weigh can, a few

drops of rennet added, the cover screwed down tightly and the can stood up in a bath of warm water. When properly thickened the curd was broken by shaking and the whey expelled by agitation and heat. When the curd was dry enough the can was opened, the whey poured off, and the curd salted and pressed by hand in small cheese-cloth bags. A quart of milk produced a cheese slightly smaller than a base ball.

Up to the time the can was opened to remove the whey the curd was entirely protected from contamination. Some chance for contamination was unavoidable during the pressing process, which was accomplished with the hands. The hands were washed before handling each cheese, and in order to determine whether *B. rudensis* was carried in this way, a record was kept of the order in which the cheeses were pressed. On comparing this order with the results of the examination of the cheese it was found that in only a small number of cases could red spots be found in the cheese handled next after those abundantly seeded with *Bacillus rudensis.*

The point of prime importance in the preparation of these cheeses was to remove a sufficient amount of water from the curd before enough acid had formed to cause the curd to "string" on the hot iron. The formation of greater quantities of acid for some reason prevented the development of spots. Since the work was carried on without opening the cans considerable skill was necessary, and our success varied greatly at different times. Whenever we obtained the development of a fair amount of red spots in the cheese we assumed that the milk contained *Bacillus rudensis,* but in cases where no spots appeared we could not say with certainty whether the germs were absent or had been prevented from showing by unfavorable conditions in the cheese.

*Results of this test in 1902.*—During the past season we have used this method of testing the milk of some of the patrons at Factory Number Four on a number of days. Our object in repeating the test was to determine, if possible, how constantly certain dairies furnished starters of *Bacillus rudensis,* and also whether there is any relation between the amounts present in the milk from the patrons and the extent of the discoloration formed in the cheese of that day.

## Rusty Spots in Small Cheeses.

— = No red spots found.
+ = Less than a dozen red points found.
+? = Single point or points located outside of cheese.
++ Points intermediate in number.
+++ Points very abundant.

| No. | Aug. 5-6. | Aug. 21. | Aug. 22. | Aug. 23. | Sept. 4-5. | No. | Aug. 5-6. | Aug. 21. | Aug. 22. | Aug. 23. | Sept. 4-5. | No. | Aug. 5-6. | Aug. 21. | Aug. 22. | Aug. 23. | Sept. 4-5. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ++ | ..... | — | ++ | — | 31 | — | .. | .. | .... | .. | 61 | ++ | .. | — | — | .. |
| 2 | ..... | ..... | — | .... | .. | 32 | — | .. | .. | .... | .. | 62 | + | .. | — | — | .. |
| 3 | ..... | ..... | ..... | ++ | — | 33 | + ? | .. | — | ++ | .. | 63 | — | .. | — | ..... | .. |
| 4 | ..... | ..... | — | .... | .. | 34 | — | .. | .. | .... | .. | 64 | ..... | .. | .. | + | .. |
| 5 | +++ | ..... | — | ++ | — | 35 | .... | .. | .. | — | .. | 65 | — | .. | .. | ..... | .. |
| 6 | + | ..... | — | ++ | — | 36 | — | .. | .. | .... | .. | 66 | — | .. | .. | ..... | .. |
| 7 | — | ..... | — | .... | .. | 37 | — | .. | .. | .... | .. | 67 | + | — | — | ++ | — |
| 8 | — | ..... | ..... | .... | .. | 38 | — | .. | .. | .... | .. | 68 | — | .. | .. | ..... | .. |
| 9 | — | ..... | ..... | .... | .. | 39 | — | .. | .. | .... | .. | 69 | — | .. | — | ..... | .. |
| 10 | — | — | ..... | .... | .. | 40 | — | .. | .. | .... | .. | 70 | ..... | .. | .. | +++ | .. |
| 11 | +++ | ..... | — | ++ | + | 41 | — | — | .. | .... | .. | 71 | ..... | .. | .. | — | .. |
| 12 | ..... | ..... | — | .... | .. | 42 | — | .. | .. | .... | .. | 72 | — | .. | .. | ..... | .. |
| 13 | ..... | ..... | ..... | — | .. | 43 | — | .. | .. | .... | .. | 73 | — | .. | .. | ..... | .. |
| 14 | — | ..... | ..... | .... | .. | 44 | — | — | .. | .... | — | 74 | +++ | — | .. | ..... | .. |
| 15 | — | ..... | ..... | .... | .. | 45 | — | .. | .. | .... | .. | 75 | — | .. | — | — | .. |
| 16 | ..... | ..... | — | .... | .. | 46 | .... | — | .. | .... | .. | 76 | — | .. | .. | ..... | .. |
| 17 | — | ..... | ..... | .... | .. | 47 | — | + | .. | .... | .. | 77 | ..... | — | — | ..... | .. |
| 18 | +? | ..... | ..... | ++ | .. | 48 | — | .. | — | .... | — | 78 | ..... | .. | .. | — | .. |
| 19 | — | ..... | ..... | .... | — | 49 | — | — | .. | .... | — | 79 | — | .. | .. | ..... | .. |
| 20 | + | ..... | — | — | .. | 50 | .... | .. | — | .... | .. | 80 | — | .. | — | ..... | .. |
| 21 | — | ..... | ..... | .... | .. | 51 | + | .. | — | .... | .. | 81 | — | .. | .. | ..... | .. |
| 22 | — | ..... | ..... | .... | .. | 52 | — | .. | .. | .... | .. | 82 | ..... | .. | .. | +++ | .. |
| 23 | + | — | — | .... | .. | 53 | — | .. | .. | .... | .. | 83 | ..... | .. | — | ..... | .. |
| 24 | ++ | +++ | +++ | — | — | 54 | .... | .. | — | .... | .. | 84 | — | .. | .. | ..... | .. |
| 25 | — | ..... | ..... | + ? | .. | 55 | — | .. | .. | .... | .. | 85 | — | .. | .. | ..... | .. |
| 26 | ..... | ..... | — | .... | .. | 56 | — | .. | .. | .... | .. | 86 | +? | .. | — | ..... | .. |
| 27 | — | — | ..... | .... | .. | 57 | — | — | .. | .... | .. | 87 | — | — | — | — | .. |
| 28 | + | +++ | — | — | .. | 58 | — | .. | .. | .... | .. | 88 | ..... | .. | .. | — | .. |
| 29 | — | ..... | ..... | .... | .. | 59 | — | .. | .. | .... | .. | 89 | ..... | .. | .. | + | .. |
| 30 | — | ..... | — | — | .. | 60 | .... | .. | .. | + | .. | 90 | ..... | .. | .. | +++ | .. |

In considering these results it should be remembered that we were able to handle samples from only about one-third of the patrons on any one day.

Taking the results on different days, as shown in the above table, it will be seen that the positive results were most marked on August 5 and 6 and August 23. It so happened that there was a sharp outbreak in the factory cheese of August 5 and 6, and the samples of those days marked +++ were completely filled with closely-set red points, indicating that these dairies had furnished, on these days, a heavy starter of *Bacillus rudensis*.

Much less discoloration developed in the factory cheese of August 21 to 23, and while there was a moderate number of red points present in the samples from a considerable number of patrons on these days, the contamination in individual cases did not appear to be as heavy as on August 5 and 6.

The factory cheese of September 4 and 5 was almost entirely free from red points, and it will be observed that these were also lacking in the test cheeses of these dates.

The difference in the results of August 21 and 23 can be partly accounted for on the basis of difference in manufacture. While there were good individual cheeses on each day, the formation of acid in the cheese of August 21, taken as a whole, was too great. The cheeses of August 22 averaged much better in this respect, and those of August 23 were, everything considered, the best which we have succeeded in making.

It will be further observed that in no case did any one patron respond positively to four or more consecutive tests. This failure to respond in some cases may be ascribed to lack of success in preparing the small cheese, but these results accord well with our observations in the factory, to the effect that the introduction of *Bacillus rudensis*, at least in appreciable quantities, occurs only spasmodically. A failure to respond in three or more consecutive tests is shown in a number of instances.

## WHAT IS THE SOURCE OF THE CONTAMINATION?

The presence of rusty spots in the cheese points to the factory as the source of supply of *Bacillus rudensis.*

The curd mill is a utensil peculiarly difficult to clean in the ordinary way and our experience at Factory Number One indicates that at times this may harbor a large growth of *Bacillus rudensis.* At the time of a small outbreak at Factory Number Four in 1902, red discolorations were observed on the wooden followers of the cheese hoops. The hoops, cloths and followers were thoroughly steamed and the spots did not appear in the cheese of the succeeding days. The fact that a thorough steaming of the vats and tools rapidly cuts down the number and importance of the spots strengthens the belief that under ordinary conditions the main seed bed of infection is in the factory.

However the sudden appearance of a large number of red points in the cheese from a single vat when the product of the remaining vats was nearly or quite free from the trouble points to an outside source of contamination. The presence of a considerable number of red points in the test cheese made direct from the milk of the individual patrons, together with the fact that these points were especially numerous just at the time when the spots were abundant in the product of the factory, makes it fairly certain that at times considerable quantities of *Bacillus rudensis* are brought to the factory by some of the patrons.

The next step is to determine when and under what conditions *Bacillus rudensis* gains entrance to the milk. Considerable work in this connection has already been done but the data collected were not sufficient to warrant drawing safe conclusions when the lateness of the season put a stop to this phase of the investigation.

In no case have we found evidence to warrant us in deciding whether *Bacillus rudensis* first gained a foothold in a dairy or at the factory. In either case, under ordinary conditions the factory often offers a suitable seed bed and the germs thrive there abundantly. At the time of making the cheese a considerable number of these germs pass off with the whey. These are taken by the patrons with the whey to their farms and fed to the young animals and in so doing the region around the barns becomes

more or less seeded. The exact conditions which bring about a seeding of the milk of any dairy have not been worked out in detail. The facilities for washing the cans at the farms are not such as to insure the removal of all the germs which were in the whey, and a portion of the trouble may be accounted for in this way. However the appearance of *Bacillus rudensis* in the milk at such irregular intervals and at times in such quantities has led us to look for seed beds at the dairy from which occasionally the milk receives a heavy inoculation.

## CONCLUSIONS AND RECOMMENDATIONS.

As the result of our experience during the past two seasons we feel assured that under all but very exceptional circumstances thorough steaming at the factory will control the rusty spots and keep them below the point where they will cause financial loss. Just as is the case with the spraying of fruit or vegetables the success attained will depend largely upon how thoroughly the directions are followed.

In attempting to combat this trouble in any factory the first step is a thorough cleaning up of the factory and its surroundings. A few loads of gravel will do away with the mud by the weigh can and the whey tank and good drainage should be provided for the factory waste. The walls and ceiling of the room in which the cheese is made should be cleaned and preferably whitewashed and the floor scrubbed with hot lye.

The weigh can and all the utensils which come in contact with the milk should be steamed thoroughly three times per week. This can be best accomplished by placing the utensils in a vat, drawing a heavy canvas cover tightly over the top and turning in the steam. In five minutes the heat should be up to 180° F. in all parts of the vat, and fifteen minutes more above this temperature will suffice. The weigh can is best treated by inverting and turning in the steam for twenty minutes through the faucet. The heating of the all metal cheese hoops can be carried out according to the same plan, but Frasier hoops present some difficulties. The accumulation of fat in the crevices makes a special place for heating desirable, and our experience in heating

the wooden followers is not sufficient to justify us in recommending it as a regular procedure although heating occasionally does not seem to be harmful. The observations given in connection with Factory Number Four indicate that heating these followers is desirable.

Considered both as a means of preventing the return of a considerable number of *Bacillus rudensis* to the farms and as a means of holding the whey sweet and in first-class condition for feeding, the heating of the whey to 160° F. is desirable. Unfortunately in our attempts thus far we have been compelled to stop the heating because of the leaking of the vat before we had a chance to make a fair test of its effect upon the spread of the trouble.